ASSAP Action Item #6:

Propose Strawman Best Track Source Selection Logic

RTCA SC-186 WG-4 Meeting
ASSAP Subgroup

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Presentation Outline

- **Need for Best Track Selection Logic**
  - **Motivation for requiring**
  - **Scope of the track selection**
- **Background / Recall ASA MASPS Requirements**
  - **ASSAP "Surveillance Processing" Requirements**
  - **Existing ASA MASPS "Transmit" State Data Source Selection**
    - Similar requirements appropriate for ASSAP "Receive" processing when multiple tracks are available
- **Discuss What Determines the "Best" Track**
- **Proposed Strawman Best Track Selection Logic**
  - **Baseline for us to discuss and modify as appropriate**
  - **Once committee agrees on the basic logical approach for source track selection, then we can develop the "shall" requirements**

Need for Best Track Selection Logic Motivation

- **ASSAP may receive multiple tracks for the same traffic target**
  - **When multiple tracks for the same aircraft are provided to the ASSAP (e.g., ADS-B, TIS-B, and TCAS), it is required that ASSAP correlates the tracks and selects only one track for ASA processing and display on the CDTI**
  - **The subject of this presentation is to propose a strawman for selecting the "best" track, after it has been determined that two or more tracks are the same aircraft**

ASSAP Needs Best Track Selection Logic

Need for Best Track Selection Logic Scope

- **Per the current requirements, ASA Applications can only be “run” with traffic targets received via ADS-B and TIS-B (i.e., not TCAS)**
  - **<u>Thus, ASSAP processing has to select/blend between ADS-B and TIS-B tracks (cannot select TCAS track)</u>**
  - **“All” received TCAS traffic targets must still be covered with standard TCAS collision avoidance algorithms (TCAS functional requirement)**
    - TCAS processing “may” in a future be disabled on a few select TCAS traffic targets to support some of the more advanced ASA applications (e.g., parallel runway approach). This is not an issue that needs to be addressed in the first version of the MOPS, because we are not intending to support such applications, but needs to be addressed in the future.

Best Track for ASA Applications must be based upon ADS-B and/or TIS-B

Recall: Relevant ASA MASPS Requirements for ASSAP Surveillance Processing

- **ASA MASPS "Requirements for ASSAP"** ***(2.4.3.4 page 46)***

The two major functions of ASSAP are *surveillance processing* and *applications processing.* Requirements for ASSAP are described in §3.3.2.

Surveillance processing:

- Establishes tracks from ADS-B and TIS-B traffic reports;
- Cross-references traffic from different surveillance sources (ADS-B, TIS-B, and TCAS)
- Estimates track state (e.g., position, velocity), and track quality.
- Deletes tracks that are beyond the maximum allowable coast time for any ASA applications

Applications processing:

- Determines the appropriateness of track information for various applications, and forwards the track data to the CDTI
- Performs alerting functions for e.g., CD, ACM, and ICSPA
- May derive guidance information for various future applications, e.g., ASIA.

ASSAP is supported by navigation information from own-ship. Each ASA participant **should** input to ASSAP the highest quality state data that is available on-board; this information **should** be the same as that used for ADS-B transmission. See §2.4.2 for guidance on highest quality source selection. ASSAP **shall** (R2.27) assess the ability of own-ship and traffic targets to support the active applications or applications within an active ACL by assessing own-ship performance and transmitted data quality as specified in Table 2-4 and received traffic-ship data quality as specified in Table 2-1.

Recall: Relevant ASA MASPS Requirements for ASSAP Surveillance Processing

- **ASA MASPS "Requirements for ASSAP"** ***(3.3.2.1.1 page 108)***

1. ASSAP **shall** (R3.1) provide a tracking function. The tracking function:

   …

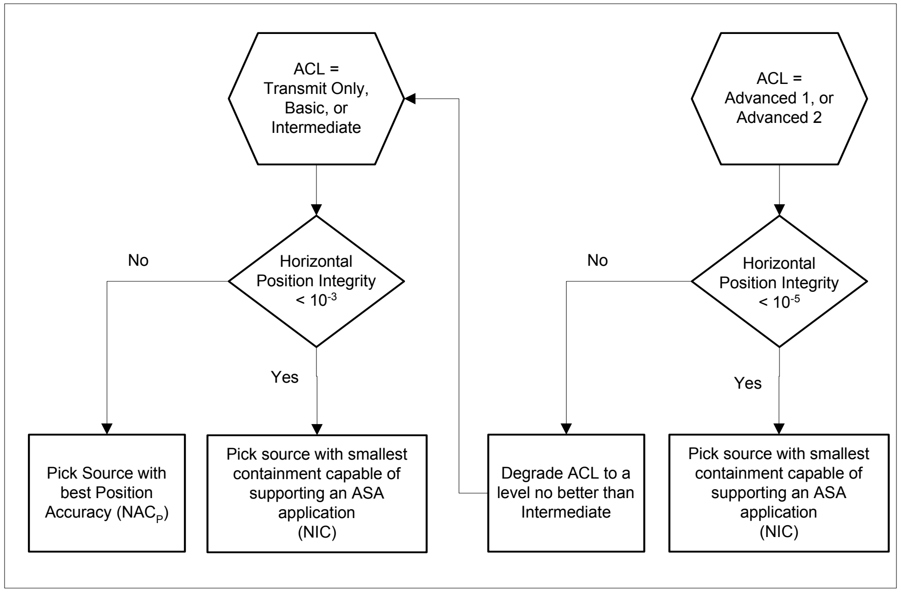
   f. **Shall** (R3.174) include an estimation function that estimates track state based on one or more surveillance source inputs. Track state includes time of the state estimate, horizontal position, horizontal velocity, altitude, altitude rate, heading (if possible), and track quality, including accuracy, integrity containment boundary, and integrity containment risk (see §2.4.5.3).

   The estimation function may combine information from different data sources in order to improve the track state estimate. ASSAP surveillance processing **shall** (R3.175) optimize the quality of the information best suited to the applications being run (e.g., accuracy, integrity containment bound, or integrity containment risk). ASSAP may enhance the quality of the track information, using techniques such as Kalman filters. ASSAP **shall** (R3.176) estimate the quality of the track state information that is maintained in the track file, and maintain quality measures for the track state information, as indicated in Table 3-15.

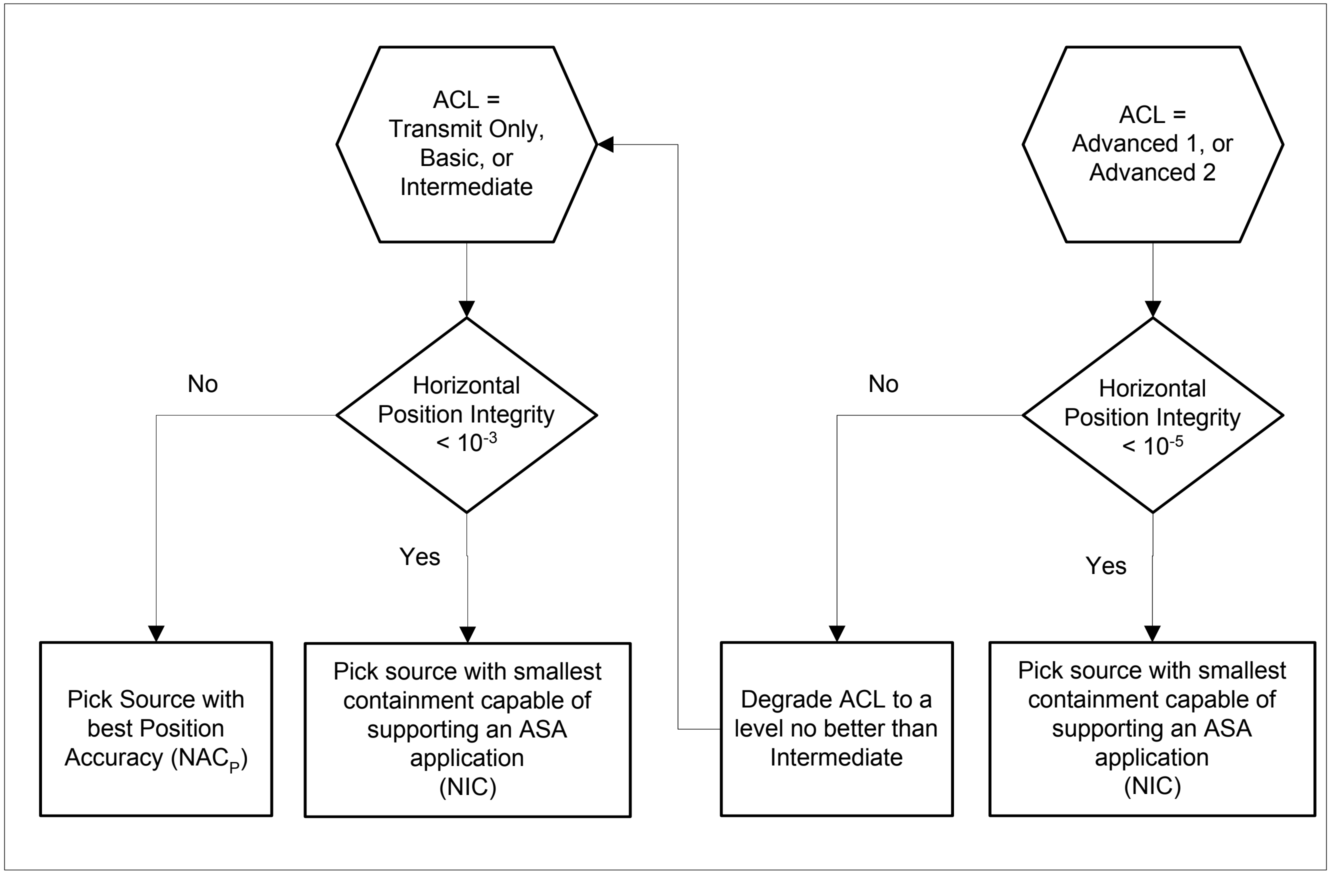
   Note: The fusion of TCAS measurements with ADS-B or other data is the subject of continuing debate and will be treated in the ASAS MOPS.

Recall: ASA MASPS "Transmit" State Data Source Selection

- **Transmit Source Selection to Determine "Highest Quality" (i.e., best) State Data for Transmission is Similar to Receive Best Track Selection**
- **Requirements for Data Transmission *(2.4.2 page 44)***
  - **"… transmit the highest quality state data that is available …"**
  - **Example State Data Transmit Source Selection Logic (Figure 2-8)**
    - See next page for a larger version of the Figure Below



ASA MASPS "Transmit" State Data Source Selection Logic (Figure 2-8)



Several ASA MASPS Authors identified a problem (post approval)

- **For valid sources, first pick source that would lead to highest TQL (does not combine data from multiple navigation sources)**
- **Then, if multiple sources are still possible, select based upon best integrity and accuracy**

What Determines the "Best" Track?

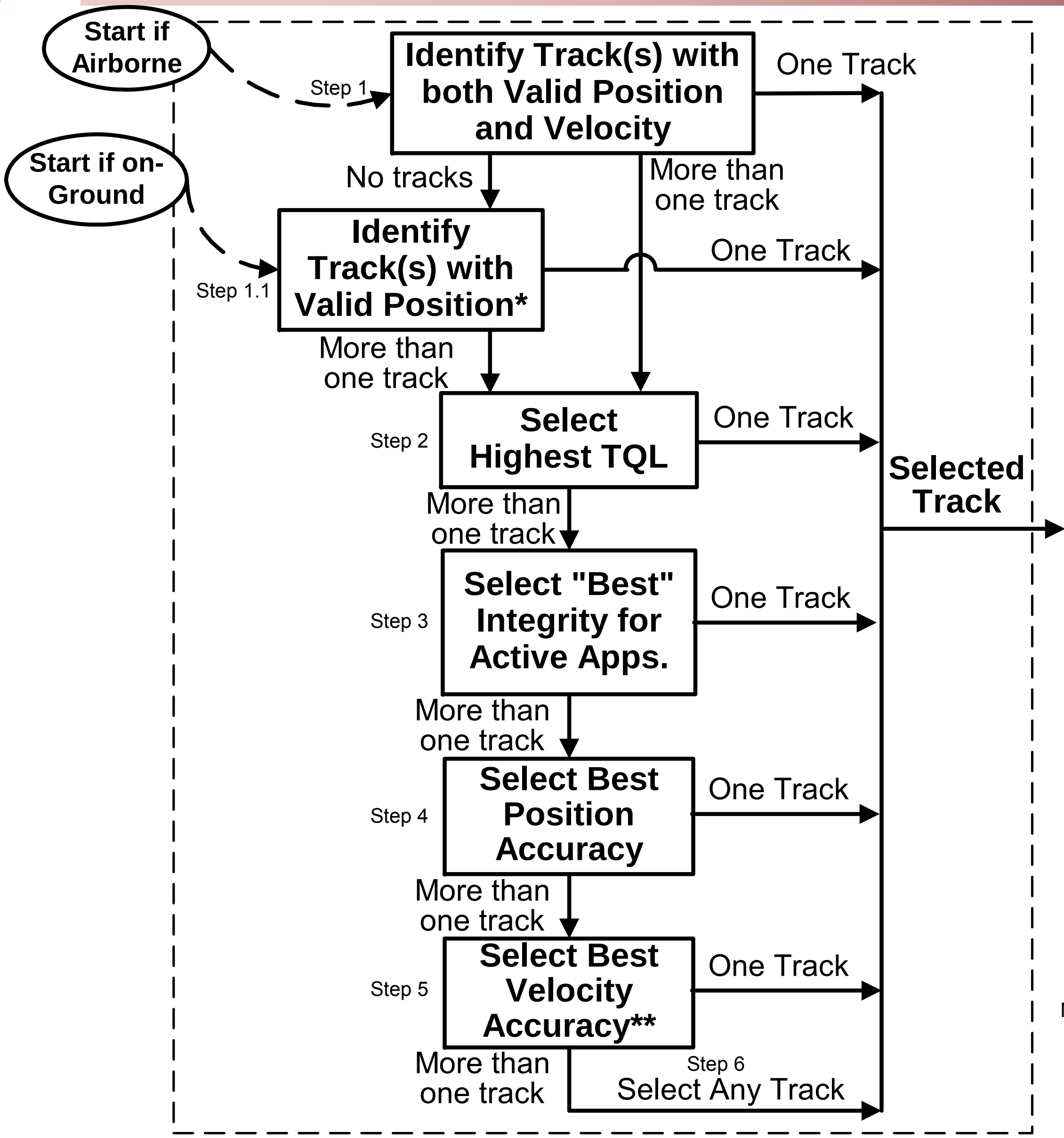
- **Best track is the one that is "best" for how the information is used**
  - **"Best" depends on how the information is Used**
    - In other words, the best information is application dependent
      - For example, for some applications (e.g., surface situational awareness), we "may" be willing to live with somewhat lesser integrity to get better accuracy
      - When multiple applications are active, so it is "possible" (but <u>not</u> proposed) that different active ASA applications use different tracks [i.e., best track for each active application]
  - **"Best" Track is generally one with the highest state data quality and / or complete information content *(generally leads to best application performance)***
    - Indicators of State Data Quality:
      - Validity of State Data (Position and Velocity)
      - Integrity/Accuracy/Continuity/Latency: TQL, SIL, NIC, NAC_P, NAC_V
    - Does the Track have a complete set of information?
      - Include all data fields (e.g., Flight ID / Call Sign)
      - If we determine two tracks are the same, can we augment report information (use state data from one, but flight ID or Length/Width code from the other, etc.)?
        - In general ADS-B will be better than TIS-B, but not always. TIS-B based upon ASDE-X on the surface may have better state data than ADS-B.
  - **May be able to get a better track estimate by appropriately weighting information from two or more tracks for the same aircraft (or vehicle)**
    - Possible, but <u>not</u> proposed for a variety of reasons

Propose the following guidelines for the "Best Track Selection Logic"

- **Select one "Best" Track that is used for all active ASA applications**
  - **Propose selecting the best track, not using a Kalman filter to weight information from two or more tracks**
  - **Propose not optimizing "best" track for each active application**
    - Proposed that one Track is selected and used for all active applications
  - **Rationale: Minimize complexity**
    - Requirements, implementation, testing, human factors issues (e.g., which "best" application track gets displayed), etc.
- **Proposed Screening Basic Approach**
  - **4 Screening levels in selection**
    - State Data Validity
    - TQL *(Note: All current Link MOPS are interpreted as TQL=0)*
    - Integrity
    - Accuracy

Propose a balanced compromise between "minimize complexity" and selecting the best track in all situations

Proposed ASSAP Track Selection for Multiple ADS-B / TIS-B Tracks of the Same Aircraft



Notes:
* Not a valid track without valid position.
** This step skipped when velocity is not valid.

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Proposed Track Selection for Multiple Tracks of the Same Aircraft

- **Selection Process (Until one "best" track is available)**
  - **1) Select Track with both Valid Position and Velocity State Data**
    - Airborne: First select sources that have both valid position and velocity. If there are none, then just select sources that have valid "position".
    - Ground: Select sources with valid position.
    - Without "valid" position, there is no valid track.
  - **2) Select Track with highest TQL**
    - All current ADS-B and TIS-B Link MOPS are interpreted as TQL=0. Future revisions of the Link MOPS are expected to comply with the ASA MASPS TQL.
  - **3) Select Track with best integrity for most stringent Active ASA Application**
    - For tracks with SIL ≥ 1, select track with smallest containment region (highest NIC)
      - SIL ≥ 1 satisfies Basic and Intermediate ASA applications requirements
      - When the ASSAP MOPS is written to address higher ACLs, then we may need to expand the integrity screening of step 3 (e.g., first select tracks with SIL ≥ 2) to satisfy the "shall" requirement to optimize the track selection to the applications being run
  - **4) Select Track with best position accuracy (highest NAC_P)**
  - **5) Select Track with best velocity accuracy (highest NAC_V)**
  - **6) If more than one track is still available, select any of the tracks that remain. They are equivalent.**
    - Would like to select ADS-B Track over TIS-B Track [if known]
      - Rationale: TIS-B probably has more lag with all the other parameters equal

See diagram on the previous page

Proposed Track Selection Discussion

- **Proposed Selection Process**
  - **Rationale for proposed airborne / on-ground complication (Valid position vs. both valid position and velocity track)**
    - Consider the following example:
      - Two tracks: One has both valid position and velocity, but poor quality. Second track does not have valid velocity, but has high quality position information.
      - This example is a very real possibility with an ASDE-X TIS-B track (without velocity) on the airport surface. Likely better to select better source of position, than source with both position and velocity.
  - **Do not recommend weighting data from multiple Tracks on the same traffic target**
    - Mostly disadvantages, adds complexity. Track “selection” recommended.
  - **May not be optimal in all corner conditions**
    - Could further complicate track selection using data age
      - Track quality degrades with age. However, using data age will tend to cause flipping back and forth between multiple tracks based upon the latest received update.
      - Perhaps this needs additional consideration
- **Advantages of Proposed Approach**
  - **Simplicity**
    - Although many might think it is too complex as proposed
  - **Balanced the selection process complexity with selecting the “best” track in all corner conditions, while simultaneously meeting all the ASA MASPS requirements**

Conclusion / Summary

- Strawman "Best Track Selection Logic" has been proposed when multiple Tracks are available for the same aircraft
- Request committee review and feedback
  - Expect some pushback on the number of possible steps in the selection process
  - Believe it is a good compromise between best track selection and complexity
- Discussion Items
  - Further discuss alternative track selection pros and cons
  - Frequency of running selection logic / hysteresis in selection

Strawman Best Track Selection Logic Proposed.
It provides a baseline to discuss and modify as appropriate.
Let's work together to improve.

Backup Slides

Recall Quality Parameters
TQL = Transmit Quality Level
(ASA MASPS p. 65)

Characteristic	Section Reference	Transmit Quality Level [Note 1]: 1	2	3	4
Minimum ASA Transmit Equipment Integrity Risk B1→ D B2→ D [note 2]	§3.1.1.1	$\le 10^{-3}$ per hour	$\le 10^{-5}$ per hour	$\le 10^{-5}$ per hour	$\le 10^{-7}$ per hour
Minimum ASA Transmit Continuity of Service Risk A1→ D A2→ D [note 2]	§3.1.1.2	$\le 10^{-3}$ per hour		$\le 10^{-5}$ per hour	$\le 10^{-7}$ per hour
Maximum ASA Transmit Data Latency B1→ D	§3.1.1.3	< 1.1 s		< 0.3 s	
Maximum ADS-B State Data Latency A1→ B1	§3.1.1.4	< 1 s		< 0.2 s	
Maximum TIS-B State Data Latency A2→ D [note 3]	§3.1.1.5	< 3.25 s	< 2.1 s	< 1.5 s	
Minimum Time Accuracy of State Data	§3.1.1.6	< 1 s 95%		< 0.1 s 95%	
Minimum NAC_p	§3.1.1.7	≥ 5	≥ 7	≥ 7	≥ 9
Minimum NAC_v	§3.1.1.8	≥1		≥2	≥3
Minimum NIC	§3.1.1.9	≥ 5	≥ 7	≥ 9	
Minimum SIL	§3.1.1.10	≥ 1	≥ 2	≥ 2	3
Maximum time to Indicate Integrity Change A1→ D A2→ D [note 4]	§3.1.1.11	≤ 12.1 s		≤ 10.5 s	

Recall Quality Parameters
NIC = Navigation Integrity Category

NIC (Note 1)	Horizontal and Vertical Containment Bounds	Comment
0	$R_C \geq 37.04$ km (20 NM)	Unknown Position Integrity
1	$R_C < 37.04$ km (20 NM)	RNP-10 containment radius
2	$R_C < 14.816$ km (8 NM)	RNP-4 containment radius
3	$R_C < 7.408$ km (4 NM)	RNP-2 containment radius
4	$R_C < 3.704$ km (2 NM)	RNP-1 containment radius
5	$R_C < 1852$ m (1 NM)	RNP-0.5 containment radius
6	$R_C < 1111.2$ m (0.6 NM)	RNP-0.3 containment radius
7	$R_C < 370.4$ m (0.2 NM)	RNP-0.1 containment radius
8	$R_C < 185.2$ m (0.1 NM)	RNP-0.05 containment radius
9	$R_C < 75$ m and VPL < [112 m]	e.g., WAAS HPL, VPL
10	$R_C < 25$ m and VPL < [37.5 m]	e.g., WAAS HPL, VPL
11	$R_C < 7.5$ m and VPL < [11 m]	e.g., LAAS HPL, VPL

Recall Quality Parameters
SIL = Surveillance Integrity Level

SIL	Probability of Exceeding the Reported Position Containment Region without Detection
0	Unknown
1	$\leq 1 \times 10^{-3}$ per flight hour
2	$\leq 1 \times 10^{-5}$ per flight hour
3	$\leq 1 \times 10^{-7}$ per flight hour

Note: *This table is reproduced from RTCA DO-260A, Table 2-72, and is provided herein in order to provide continuity to the flow of the STP requirements. (See RTCA DO-282, section 2.2.4.5.4.6 and Table 2-44).*

Recall Quality Parameters

NAC_p = Navigation Accuracy Category for Position

NAC_P	95% Horizontal and Vertical Accuracy Bounds (EPU and VEPU)	Comment
0	EPU ≥ 18.52 km (10 NM)	Unknown accuracy
1	EPU < 18.52 km (10 NM)	RNP-10 accuracy
2	EPU < 7.408 km (4 NM)	RNP-4 accuracy
3	EPU < 3.704 km (2 NM)	RNP-2 accuracy
4	EPU < 1852 m (1NM)	RNP-1 accuracy
5	EPU < 926 m (0.5 NM)	RNP-0.5 accuracy
6	EPU < 555.6 m (0.3 NM)	RNP-0.3 accuracy
7	EPU < 185.2 m (0.1 NM)	RNP-0.1 accuracy
8	EPU < 92.6 m (0.05 NM)	e.g., GPS (with SA)
9	EPU < 30 m and VEPU < 45 m	e.g., GPS (SA off)
10	EPU < 10 m and VEPU < 15 m	e.g., WAAS
11	EPU < 3 m and VEPU < 4 m	e.g., LAAS

Recall Quality Parameters

NAC_V = Navigation Accuracy Category for Velocity

NAC_V	Horizontal Velocity Accuracy (95%)	Vertical Geometric Velocity Accuracy (95%)
0	Unknown or ≥ 10 m/s	Unknown or ≥ 50 feet (15.24 m) per second
1	< 10 m/s	< 50 feet (15.24 m) per second
2	< 3 m/s	< 15 feet (4.57 m) per second
3	< 1 m/s	< 5 feet (1.52 m) per second
4	< 0.3 m/s	< 1.5 feet (0.46 m) per second